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VEGETATION AND SNOW SAMPLING SURVEYS
near
HEMLO GOLD MINES, 1988

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TECHNICAL SUPPORT SECTION
NORTHWESTERN REGION
ONTARIO MINISTRY OF THE ENVIRONMENT
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INTRODUCTION

Ministry studies in 1984 and 1986 revealed that elevated concentrations of several elements occurred in lichens, moss and tree foliage around three gold mines in the Hemlo area, near Marathon, Ontario.[1,2]

To document the effects of any changes which may have occurred since 1986 (eg. the closing of the open-pit operation at Lac Minerals Limited), a snow sampling survey was conducted in January, 1988. This survey was followed by collection of feather moss samples in June, 1988.

METHODS

Single samples of snow were collected on January 26, 1988 from 13 sites around the gold mines (Figure 1) and from two control sites remote from the study area. Core samples of the complete snow profile were obtained following standard Ministry procedures.[3] Meltwater samples were submitted to the Ministry's Thunder Bay and Toronto laboratories for analysis of conductivity, pH, a range of metals, and the metalloid arsenic.

Feather moss (Pleurozium schreberi) was collected on June 8, 1988, from 16 locations around the mines (Figure 2) and from two distant control sites. Standard Ministry sampling procedures were followed,[3] and analysis for metals and for arsenic was performed at the Ministry's Thunder Bay laboratory.

In this report, Ministry contaminant guidelines for snow are used to interpret the data. Exceedance of a guideline may indicate a contamination problem, but is not a violation of Ministry regulations, nor does it necessarily imply human health or environmental effects. Guidelines have not yet been developed for feather moss.

RESULTS

SNOW SAMPLES

No particulate matter or discoloration was observed in the snowpack at any of the sampling sites. The depth of the snowpack averaged 72 cm and ranged from 55 to 90 cm.

Data from the snow survey are presented in Table 1. The results show that, with the exception of titanium, all parameters met applicable guidelines. Titanium exceeded the guideline at sites 2, 3 and 15, near the mines. Elevated titanium at these locations likely resulted from the presence of rock dust, road dust, or both.

Aluminum, arsenic, barium, iron, molybdenum and titanium all occurred at levels well above control values at one or more sampling sites near the mines. Antimony, cadmium, copper, mercury, vanadium and zinc concentrations at sampling sites closest to the mines were not signifcantly different from controls. Some values for conductivity (a measure of dissolved solids) were above control levels, while pH was in the normal range at all sites.

A correlation matrix of the logarithm of parameter concentrations and sampling distance from the three mines is shown in Table 2. The matrix implicates Lac Minerals as a source of aluminum, barium, cadmium, iron, mercury, titanium and zinc. Molybdenum appears to be associated with Noranda. No parameter correlated significantly with distance from Teck Corona.

The distribution pattern of aluminum concentrations in snow is shown in Figure 3. Barium, iron, molybdenum and titanium displayed similar patterns.

FEATHER MOSS SAMPLES

Vegetation at the feather moss sampling sites showed no evidence of visible air pollution injury symptoms. There was, however, light to heavy deposition of white particulate matter, possibly road dust or rock dust, on vegetation foliage at sites 2, 15 and 19 (see Figure 2). Insect damage to vegetation was light except at site 20, where caterpillar loopers had defoliated an area of mountain maple shrubs.

Analysis results for feather moss are summarized in Table 3. Concentrations of all elements, except cadmium, copper and zinc were well above controls at one or more sampling points in the study area. Log transformed concentrations of several elements, including antimony, arsenic, barium, mercury and molybdenum showed significant negative correlations with distance from the Lac Minerals headframe and open pit. Such correlations suggest that these two areas contributed to elevated readings of the elements concerned. Similar correlations were found for aluminum, barium, iron, molybdenum, nickel, vanadium and titanium, and distance from the Hemlo Gold Mines headframe. Only titanium and vanadium showed a significant relationship with distance from Teck Corona. The distribution of arsenic in the study area (Figure 4) was similar to the pattern for most of the other elements analysed.

Table 5 compares element levels in feather moss in 1984, 1986, and 1988. Compared with 1986, average antimony, arsenic and mercury levels were down significantly (50-70%) in 1988. Molybdenum and vanadium showed a moderate (20-50%) decrease, while aluminum, barium, iron and titanium averages did not change significantly. Average concentrations of all elements in 1988, however, were still above the 1984 pre-operational levels by amounts ranging from about 10% (iron) to 2700 % (molybdenum). Element levels in 1986 and 1988 were usually highest at sites 2, 3, 13, 14, and 15. At sites 19 and 21, sampled only in 1988, element levels also tended to be well above background. The seven sites with highest element concentrations are those closest to the three mines.

CONCLUSIONS

Snow and feather moss sampling surveys were carried out in 1988 near three gold mines in the Hemlo area, near Marathon, Ontario. Out of 14 parameters analysed in snow, only titanium at three sites near the mines exceeded the current guideline. Titanium is a common constituent of soil and rock and is not known to be toxic to plants or man.

Fourteen metals and arsenic were analysed in feather moss. All but three (cadmium, copper and zinc) were above normal background levels at one or more sampling sites in the study area. Correlations with sampling distance from the three mines suggested operations at Lac Minerals as the largest contributor to elevated metals, followed by Hemlo Gold and Teck Corona. Concentrations of several elements were lower in 1988 than in 1986, possibly due to the closure of the Lac Minerals open pit operation. However, elements still exceeded 1984 pre-operational levels at sample sites nearest the mines.

At the levels encountered in snow and feather moss in this survey, metals and arsenic around the Hemlo gold mines do not appear to pose a significant threat to human health or the environment. A follow-up snow sampling or terrestrial effects survey should be considered in three to five years to document any changes.

REFERENCES

1. Racette, D. J. and H. D. Griffin. 1986 Pre-operational terrestrial studies in the vicinity of Hemlo area gold mines, 1984. Ontario Ministry of the Environment.

2. Racette, D. J. and H. D. Griffin. 1988. Terrestrial air quality studies in the vicinity of the Hemlo gold mines, 1986. Ontario Ministry of the Environment.

3. Ontario Ministry of the Environment. 1983. Field investigation procedures manual. Phytotoxicology Section, Air Resources Branch.

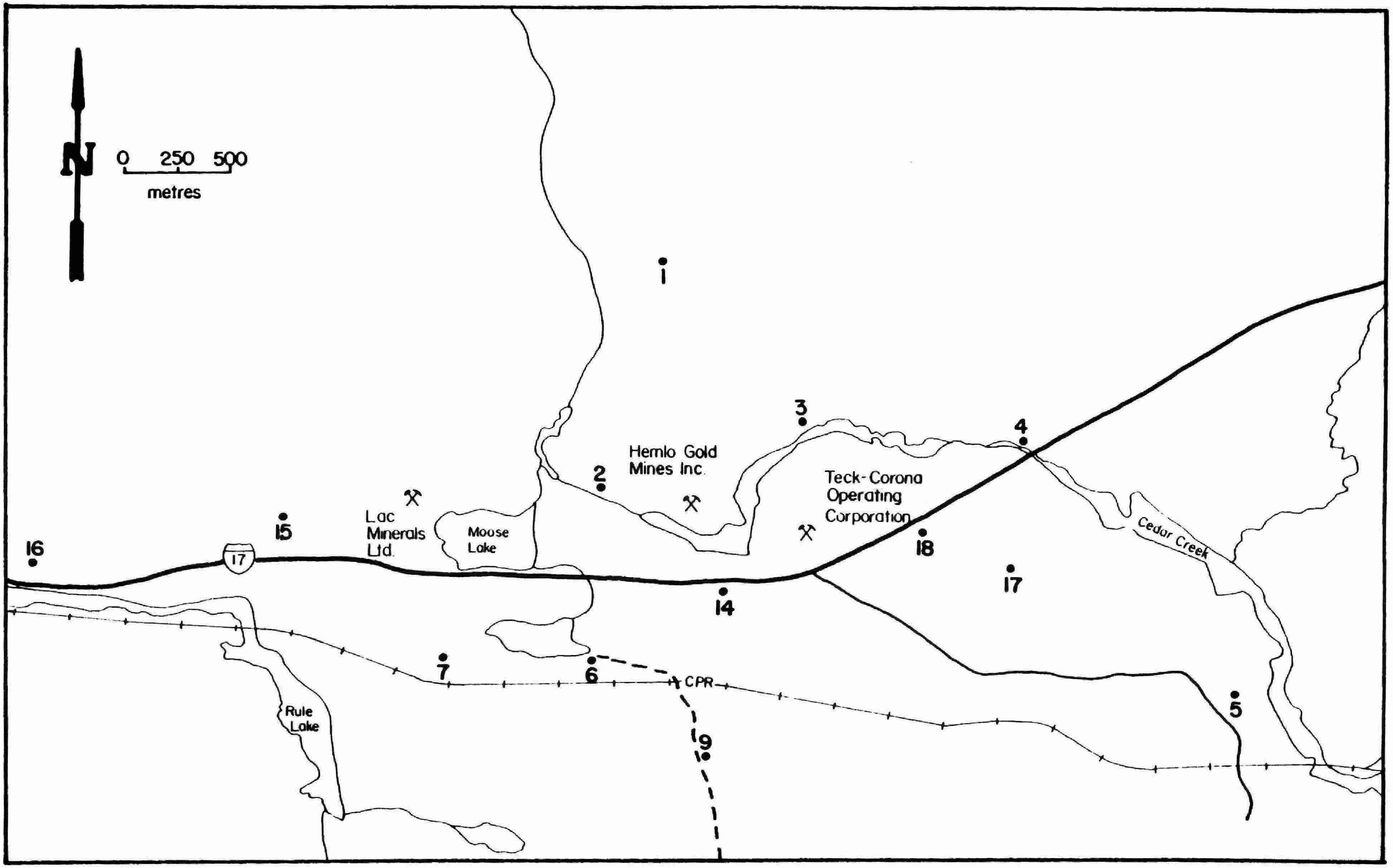

Figure 1. Snow sampling sites near the Hemlo gold mines, January 26, 1988.

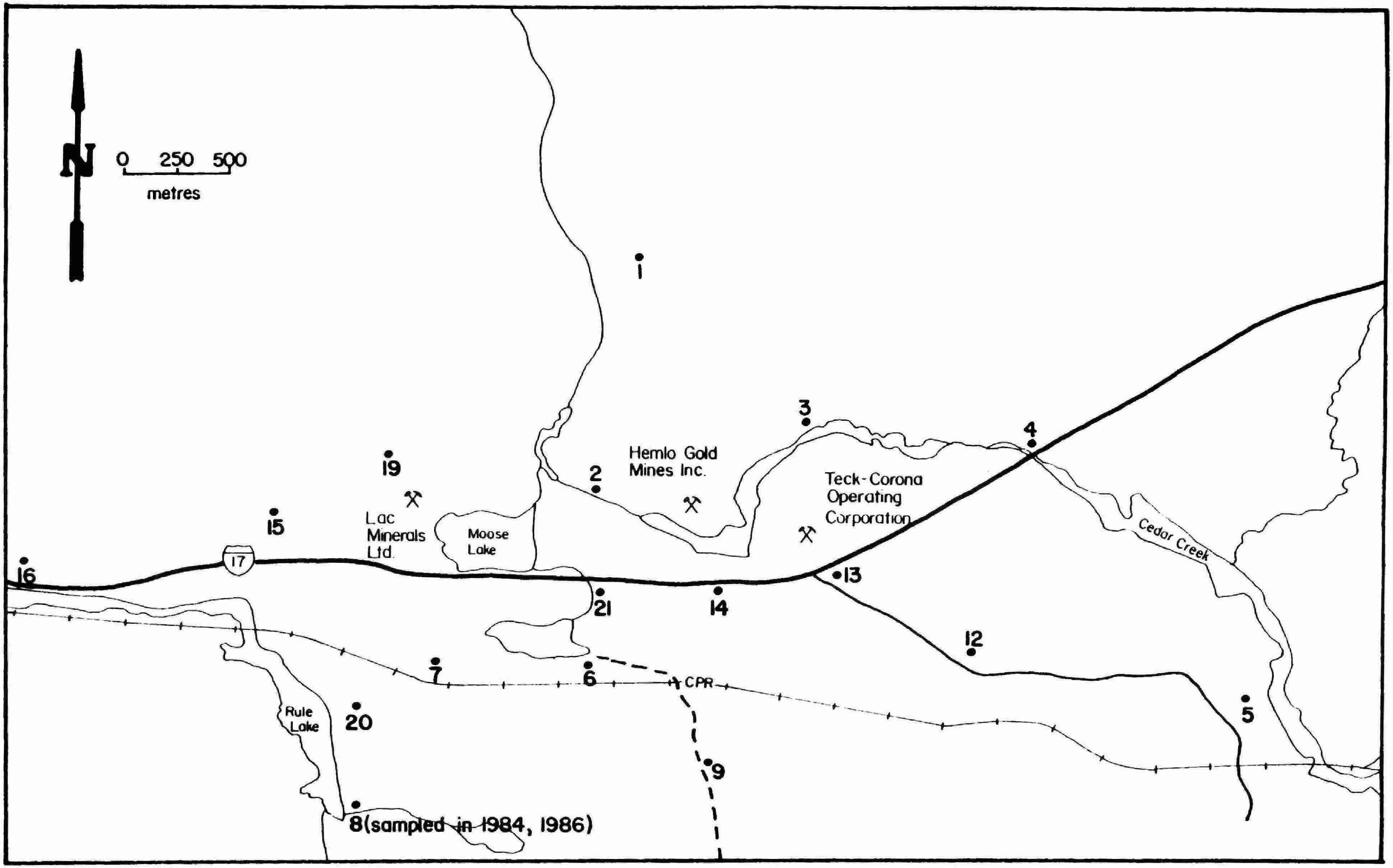

Figure 2. Feather moss (Pleurozium schreberi) sampling sites near the Hemlo gold mines, June 1988.

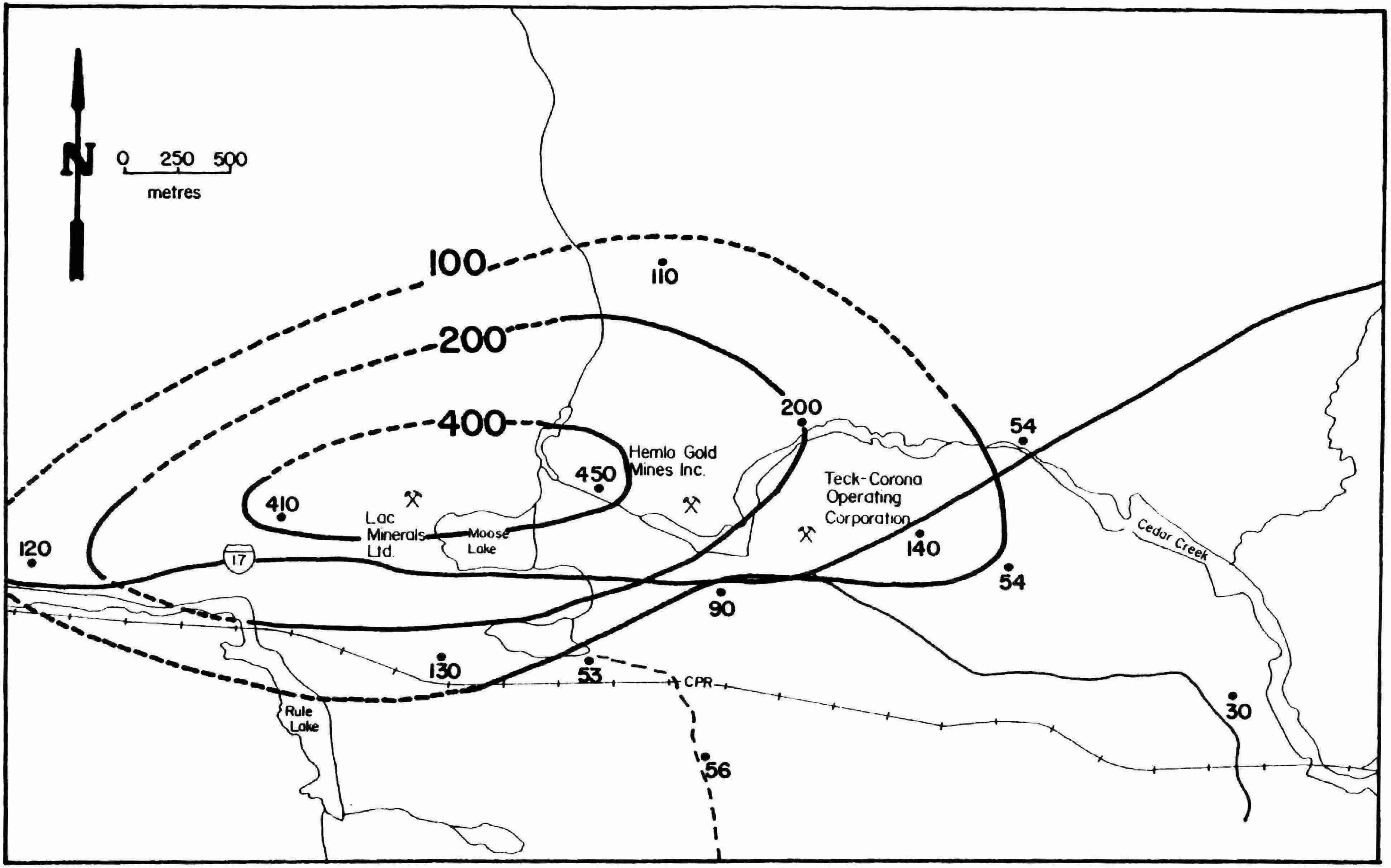

Figure 3. Levels of aluminum (µg/l) in snow meltwater near the Hemlo gold mines, January 26, 1988.

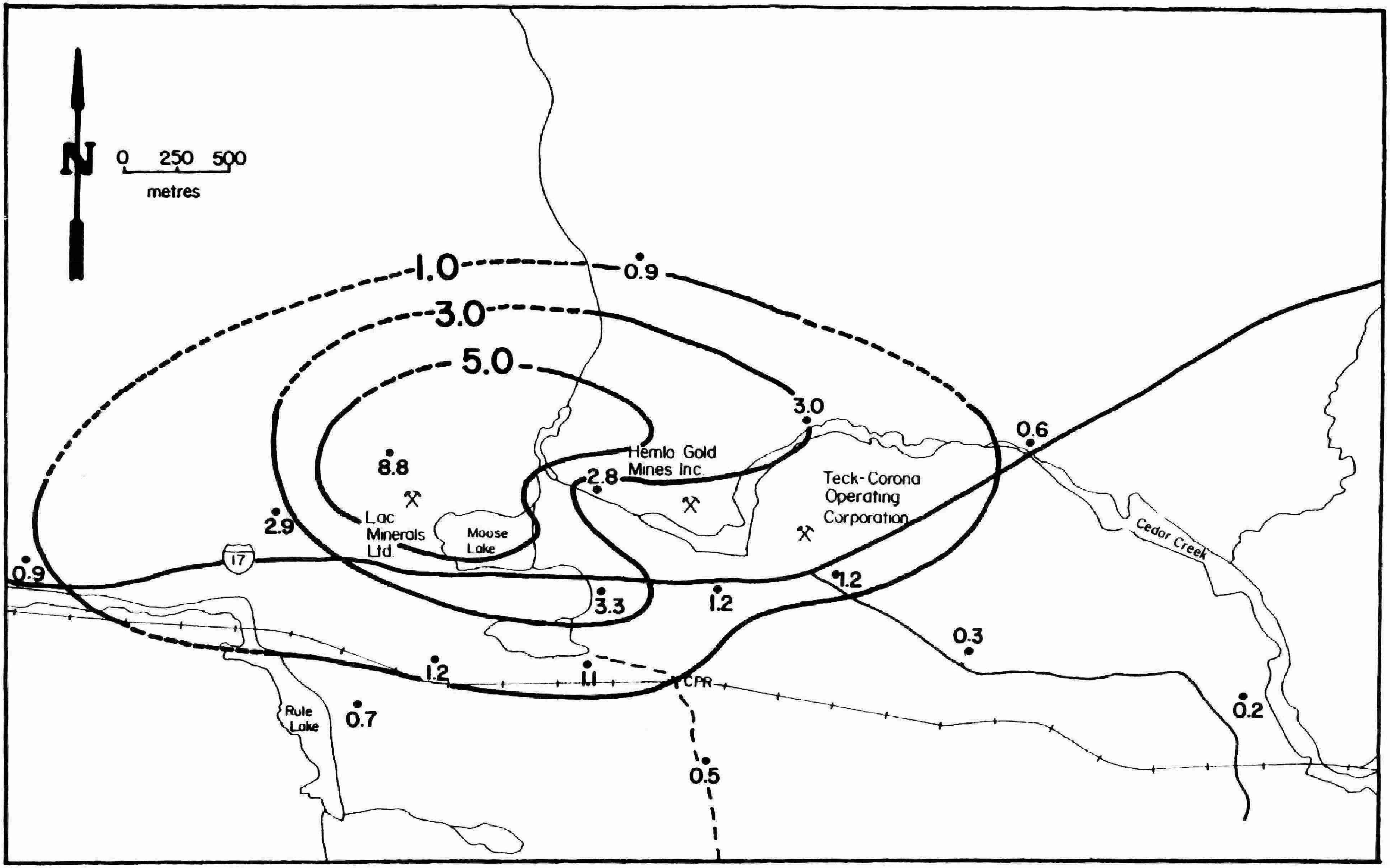

Figure 4. Levels of arsenic (µg/g, dry weight) in feather moss (Pleurozium schreberi) near the Hemlo gold mines, June, 1988.

TABLE 1. Levels of metals and arsenic (both in µg/l), conductivity (µmhos/cm) and pH in snow meltwater, Hemlo, January, 1988.

Sampling site[a]	Al[b]	Sb	As	Ba	Cd	Cu	Fe	Hg	Mo	Ti	V	Zn	Cond.	pH
1	110	<1	<1	41	<1	<1	79	<0.1	2	6	1	1	11	4.7
2	450	1	<1	91	<1	<1	350	<0.1	4	40[c]	2	2	9	5.5
3	200	<1	3	83	<1	<1	150	<0.1	4	21	2	2	11	4.9
4	54	<1	<1	19	<1	<1	59	<0.1	<1	3	1	1	16	4.8
5	30	<1	<1	4	<1	<1	38	<0.1	<1	2	<1	1	12	4.6
6	53	<1	3	17	<1	1	100	<0.1	<1	3	1	2	13	4.7
7	130	<1	<1	32	<1	3	220	<0.1	<1	8	1	8	16	4.7
9	56	<1	5	10	<1	1	58	<0.1	1	3	<1	2	13	4.7
14	90	<1	2	38	<1	1	110	<0.1	2	5	1	5	27	5.2
15	410	2	2	72	<1	2	250	0.1	1	14	1	5	[d]	[d]
16	120	<1	4	10	<1	1	150	<0.1	<1	7	1	5	39	5.5
17	54	<1	<1	12	<1	<1	51	<0.1	<1	3	1	2	10	5.0
18	140	<1	<1	24	<1	<1	140	<0.1	1	9	1	2	20	6.7
Controls	38	<1	<1	23	<1	<1	41	<0.1	<1	2	<1	2	13	4.5
Guidelines	500		30		3	60	700	0.1		10		300	45	

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[a] See Figure 1.

[b] Al=aluminum, Sb=antimony, As=arsenic, Ba=barium, Cd=cadmium, Cu=copper, Fe=iron, Hg=mercury, Mo=molybdenum, Ti=titanium, V=vanadium, Zn=zinc, Cond.=conductivity.

[c] Underlined values exceed guideline.

[d] Missing data.

TABLE 2. Correlation matrix of selected parameters in snow meltwater near the Hemlo area gold mines, January 26, 1988.

	Al[a]	Sb	As	Ba	Cd	Cu	Fe	Hg	Mo	Ti	V	Zn	Cond.
Sb	0.79*												
As	-0.11	-0.03											
Ba	0.86*	0.56*	-0.11										
Cd	0.28	0.15	0.07	0.20									
Cu	0.03	0.02	-0.06	-0.02	0.78*								
Fe	0.91*	0.60*	-0.12	0.77*	0.56*	0.34							
Hg	0.80*	0.93*	0.03	0.65*	0.28	0.12	0.66*						
Mo	0.46	-0.04	0.06	0.73*	-0.03	-0.16	0.47	0.10					
Ti	0.86*	0.40	-0.13	0.87*	0.23	-0.41	0.85*	0.45	0.75*				
V	0.64*	0.15	-0.12	0.84*	0.27	-0.10	0.64*	0.28	0.81*	0.86*			
Zn	0.21	0.26	0.09	0.10	0.73*	0.79*	0.46	0.36	-0.07	0.00	-0.04		
Cond.	-0.16	-0.27	0.36	-0.31	0.23	0.06	0.01	-0.21	-0.12	-0.24	-0.20	0.53	
pH	0.36	0.22	-0.14	0.13	0.09	-0.20	0.35	0.14	0.18	0.29	0.22	-0.00	0.38
Dist-LM[b]	-0.70*	-0.50	-0.32	-0.70*	-0.57*	-0.53	-0.81*	-0.82*	-0.20	-0.60*	-0.45	-0.66*	-0.06
Dist-HG[c]	-0.29	0.02	0.02	-0.64*	0.07	0.05	-0.28	-0.35	-0.63*	-0.37	-0.50	0.07	0.38
Dist-TC[d]	0.05	0.26	0.21	-0.33	0.32	0.29	0.11	0.03	-0.50	-0.07	-0.28	0.39	0.45

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[a] See Table 1 for full names of all parameters.

*Denotes a significant correlation for pairs of parameters at the 95% confidence level.

[b] Dist-LM: Distance between sampling sites and the headframe at Lac Minerals Limited.

[c] Dist-HG: Distance between sampling sites and the headframe at Hemlo Gold Mines Inc.

[d] Dist-TC: Distance between sampling sites and the headframe at Teck-Corona Operating Corporation.

TABLE 3. Levels of metals and arsenic (in µg/g, dry weight) in feather moss Hemlo, June, 1988.

Sampling site[a]	Al[b]	Sb	As	Ba	Cd	Cu	Fe	Pb	Hg	Mo	Ni	Ti	V	Zn
1	970	1	<1	220	<1	10	1000	1	0.5	13	2	73	3	31
2	2500	4	3	520	<1	10	3000	4	1.3	26	6	330	9	32
3	1800	2	3	490	<1	9	2300	4	0.6	28	4	210	8	37
4	720	<1	<1	130	<1	5	790	1	0.3	5	2	50	2	25
5	700	<1	<1	58	<1	10	890	1	0.1	2	2	51	1	34
6	840	2	1	180	<1	6	1000	1	0.5	8	3	57	2	33
7	1100	<1	1	360	<1	12	1600	1	0.4	9	4	86	3	31
9	830	<1	<1	91	<1	4	970	1	0.2	4	2	60	2	30
12	790	<1	<1	69	<1	6	980	1	0.1	2	2	68	2	34
13	1700	<1	1	200	<1	8	2400	6	0.3	12	5	180	6	57
14	8200	2	1	320	<1	12	7100	12	0.5	58	9	480	18	67
15	2100	3	3	400	<1	13	2500	8	1.5	19	4	170	7	34
16	810	<1	1	64	<1	25	980	8	0.2	3	2	45	2	33
19	1300	5	9	320	<1	8	1400	10	4.1	15	4	100	5	60
20	820	1	<1	190	<1	10	940	1	0.4	9	2	45	2	47
21	1800	4	3	400	<1	10	1900	6	1.8	25	6	130	6	34
Controls	560	<1	<1	35	<1	21	545	1	0.1	<1	<1	24	<1	32

[a] See figure 2

[b] See Table 1 for full names of elements, except Pb (lead) and Ni (nickel).

TABLE 4. Correlation matrix of selected elements in feather moss and distance from Hemlo gold mines, June, 1988.

	Cu	Ni	Pb	Zn	Fe	Al	As	Ba	Cd	Hg	Mo	Sb	Ti	V
Dist-LM	-0.39	-0.49	-0.40	-0.27	-0.37	-0.37	-0.79*	-0.72*	-0.36	-0.79*	-0.64*	-0.79*	-0.33	-0.46
Dist-LMP	-0.22	-0.66*	-0.27	-0.26	-0.52*	-0.52*	-0.68*	-0.79*	-0.22*	-0.67*	-0.76*	-0.74*	-0.54*	-0.63*
Dist-HG	-0.03	-0.68*	-0.18	-0.27	-0.59*	-0.60*	-0.44	-0.68*	-0.12	-0.40	-0.74*	-0.48	-0.68*	-0.71*
Dist-TC	0.21	-0.45	0.01	-0.21	-0.43	-0.41	-0.06	-0.33	0.02	-0.01	-0.43	-0.06	-0.53*	-0.50*

*Denotes a significant correlation between pairs of parameters at the 95% confidence level.

Dist-LM: Distance between sampling sites and the open pit at Lac Minerals Limited.
Dist-LMP: Distance between sampling sites and the headframe at Lac Minerals LImited.
Dist-HG: Distance between sampling sites and the headframe at Hemlo Gold Mines Limited.
Dist-TC: Distance between sampling sites and the headframe at Teck-Corona Operating Corporation.

TABLE 5. Levels of metals and arsenic ($\mu g/g$, dry weight) in feather moss, Hemlo, June, 1988.

Sampling site[a]	Aluminum			Antimony			Arsenic			Barium			Iron		
	84	86	88	84	86	88	84	86	88	84	86	88	84	86	88
1	1100	920	970	<1	1	1	<1	1	<1	62	140	220	820	1200	1000
2	1500	2900	2500	<1	7	4	<1	8	3	160	480	520	1300	2800	3000
3	1500	2100	1800	<1	2	2	<1	3	3	78	310	490	900	2500	2300
4	750	1300	720	<1	<1	<1	<1	<1	<1	69	54	120	710	1700	790
5	490	750	700	<1	<1	<1	<1	<1	<1	41	53	58	510	1000	890
6	530	1700	840	<1	5	2	<1	5	1	72	280	180	650	1600	1000
7	690	1400	1100	<1	6	<1	<1	5	1	80	340	360	840	1900	1600
8	1300	1300	-	<1	1	-	<1	<1	-	85	130	-	830	1300	-
9	620	1500	830	<1	2	<1	<1	2	<1	120	150	91	560	1500	970
12	540	760	790	<1	<1	<1	<1	<1	<1	87	94	69	560	820	980
13	1200	2100	1700	<1	<1	<1	<1	2	1	80	160	200	1300	2700	2400
14	2100	1500	8200	<1	4	2	<1	3	1	41	410	320	830	1600	7100
15	1700	2300	2100	<1	21	3	<1	16	3	88	590	400	1300	3000	2500
16	1600	1100	810	<1	2	<1	<1	<1	<1	55	81	64	1200	1300	900
19			1300	<1		1			9			320			1400
20			820	<1		5			<1			190			940
21			1800	<1		4			3			400			1900
Controls	840	1100	560	<1	<1	<1	<1	<1	<1	110	130	35	600	1100	545

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[a] See Figure 2

TABLE 5. Continued.

Sampling site[a]	Mercury			Molybdenum			Vanadium			Titanium		
	84	86	88	84	86	88	84	86	88	84	86	88
1	0.1	0.4	0.5	<1	7	13	3	4	3	81	100	73
2	<0.1	2.0	1.3	<1	42	26	3	11	9	110	200	330
3	0.2	0.6	0.6	<1	21	28	4	10	8	120	240	210
4	0.1	0.2	0.3	<1	<1	5	1	5	2	76	160	50
5	0.1	0.4	0.1	<1	1	2	2	3	1	31	47	51
6	0.1	1.2	0.5	<1	22	8	2	6	2	42	100	57
7	<0.1	1.4	0.4	<1	20	9	2	6	3	61	110	86
8	0.2	0.3	-	2	3	-	2	5	-	57	78	-
9	0.1	0.3	0.2	<1	6	4	3	6	2	49	100	60
12	<0.1	0.2	0.1	<1	2	2	2	3	2	37	66	68
13	0.1	0.3	0.3	<1	7	12	4	10	6	81	260	180
14	<0.1	1.1	0.5	<1	19	58	4	7	18	64	92	480
15	0.2	5.4	1.5	<1	77	19	4	10	7	110	220	170
16	<0.1	0.3	0.2	<1	6	3	4	4	2	59	83	45
19			4.1			15			5			100
20			0.4			9			2			45
21			1.8			25			6			130
Controls	0.1	0.2	0.1	<1	1	<1	2	4	<1	38	85	24

[a] See Figure 2

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